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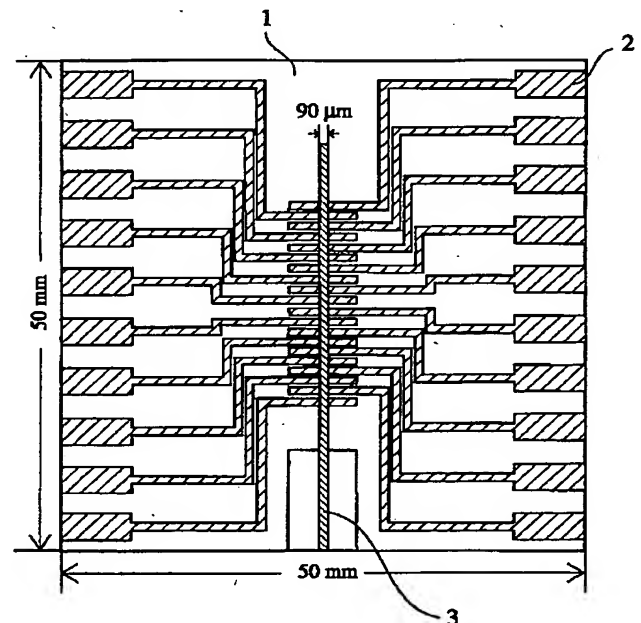
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(54) 【発明の名称】 有機電界発光素子

(57) 【要約】

【課題】 高いパワー効率を示す有機電界発光素子を提供する。

【解決手段】 2つの電極のうち少なくとも1つは光透過性の電極であり、その光透過率のピーク値が、発光スペクトルのピーク波長 $\pm 100\text{nm}$ の範囲にあり、前記光透過率のピークの半値幅が $1\text{nm}$ 以上 $350\text{nm}$ 以下である有機電界発光素子。前記光透過性の電極の表面抵抗は $15\Omega/\square$ 以下である。



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## 【特許請求の範囲】

【請求項1】 2つの電極間に少なくとも1つの有機層を有し、前記2つの電極のうち少なくとも1つは光透過性の電極である有機電界発光素子において、前記光透過性の電極の光透過率のピーク値が、発光スペクトルのピーク波長±100nmの範囲にあり、前記光透過率のピークの半値幅が1nm以上350nm以下であることを特徴とする有機電界発光素子。

【請求項2】 請求項1に記載の有機電界発光素子において、前記光透過性の電極の表面抵抗は $15\Omega/\square$ 以下であることを特徴とする有機電界発光素子。

【請求項3】 請求項1又は2に記載の有機電界発光素子において、前記光透過性の電極は2種以上の材料からなる多層薄膜であることを特徴とする有機電界発光素子。

【請求項4】 請求項3に記載の有機電界発光素子において、前記光透過性の電極は3種以上の材料からなる多層薄膜であることを特徴とする有機電界発光素子。

【請求項5】 請求項1～4のいずれかに記載の有機電界発光素子において、前記光透過性の電極は主成分がIT0、酸化インジウム、酸化スズ及び酸化インジウム酸化亜鉛合金のいずれかであることを特徴とする有機電界発光素子。

【請求項6】 請求項1～5のいずれかに記載の有機電界発光素子において、 $10^{-9}\sim 10^{-3}$ 秒のパルス幅で発光することを特徴とする有機電界発光素子。

## 【発明の詳細な説明】

## 【0001】

【発明の属する技術分野】 本発明は高いパワー効率を示す有機電界発光素子に関する。

## 【0002】

【従来の技術】 有機電界発光素子（以下、有機EL素子と称する）は、蒸着法や塗布法を用いて比較的容易に面発光素子として形成できるため、フラットパネルディスプレイ用として非常に有望視されている。近年、有機EL素子は盛んに研究されており、無機LEDに匹敵する優れた性能を有する有機EL素子が開発されてきている。

【0003】 有機EL素子は面発光素子であるので、通常2つの電極のうち一方には抵抗が低く、高い光透過率を有するものが用いられる。そのような電極としては、例えば酸化インジウムにスズがドーパされたIT0からなる電極がよく知られているが（特開平11-67460）、これよりも更に抵抗が低く効果的に光を透過する電極、及びかかる電極を用いることにより一層優れたパワー効率を示す有機EL素子の開発が望まれている。

## 【0004】

【発明が解決しようとする課題】 本発明の目的は、高いパワー効率を示す有機EL素子を提供することである。

## 【0005】

【課題を解決するための手段】 上記目的に鑑み鋭意研究

の結果、本発明者らは、2つの電極のうち少なくとも1つは光透過性の電極であり、その光透過率のピーク値が、発光スペクトルのピーク波長±100nmの範囲にあり、前記光透過率のピークの半値幅が1nm以上350nm以下である有機EL素子は高いパワー効率を示すことを発見し、本発明に想到した。

【0006】 また、本発明の有機EL素子は、以下（1）～（4）の好ましい条件を満たすことにより、一層優れたパワー効率を示す。

（1）光透過性の電極の表面抵抗は $15\Omega/\square$ 以下であるのが好ましい。

（2）光透過性の電極は2種以上の材料からなる多層薄膜であるのが好ましく、3種以上の材料からなる多層薄膜であるのがより好ましい。

（3）光透過性の電極は主成分がIT0、酸化インジウム、酸化スズ及び酸化インジウム酸化亜鉛合金のいずれかであるのが好ましい。

（4）有機EL素子は $10^{-9}\sim 10^{-3}$ 秒のパルス幅で発光するのが好ましい。

## 【0007】

【発明の実施の形態】 本発明の有機EL素子は基本的に、基板上に陽極、任意で設けるホール輸送層、発光層、任意で設ける電子輸送層及び陰極を順に積層して構成し、2つの電極間に少なくとも1つの有機層を有し、2つの電極のうち少なくとも一方は光透過性である。具体的には、陽極／発光層／陰極からなる構成、陽極／ホール輸送層／発光層／陰極からなる構成、陽極／発光層／電子輸送層／陰極からなる構成、陽極／ホール輸送層／発光層／電子輸送層／陰極からなる構成等が可能である。また、これらを基板上に逆に積層した構成も可能である。さらに、発光層、ホール輸送層又は電子輸送層を複数層設けたり、ホール注入層、電子注入層を設けてもよい。

【0008】 さらに本発明では、陽極に接して導電性高分子層を設置してもよい。導電性高分子層を設置することにより、駆動電圧がほとんど上昇することなく有機層の膜を厚くすることができ、輝度ムラやショートの原因を抑えることができる。

【0009】 上述のような構成に加え、微小光共振器構造（マイクロキャビティ）を有する有機EL素子が、発光スペクトルの半値幅が小さく、かつ指向性に優れている点で好ましい。微小光共振器構造を有する有機EL素子は、例えば「月刊ディスプレイ」1998年10月号別冊の「有機ELディスプレイ」（テクノタイムズ社）105頁に記載されているように、基板として透明基板を用い、この上に順に誘電体ミラー、透明電極（陽極）、少なくとも1層の有機層、金属ミラーの役割を有する背面電極（陰極）を積層してなり、誘電体ミラーと背面電極との間で微小光共振器を形成する。誘電体ミラーは、通常1/4波長の $\text{SiO}_2$ と $\text{TiO}_2$ を交互に積層したものである。透

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明電極 (ITO等) と誘電体ミラーとの間に $\text{SiO}_2$ スペーサーを導入して膜厚を調整してもよい。

【0010】有機層は、真空蒸着法、スパッタ法、ディッピング法、スピンコーティング法、キャスト法、法、パーコート法、ロールコート法等、公知の方法を用いて形成することができる。また溶媒を使い分けることにより多層塗布も可能である。

【0011】本発明の有機EL素子は単一の画素でも使用できるが、好ましくは発光色別に複数列設けられたドットアレイとして使用する。各発光色は1ラインでも、複数のラインになっていてもよい。1画素のサイズは、10～500 $\mu\text{m}$ 、好ましくは50～300 $\mu\text{m}$ である。

【0012】以下、本発明の有機EL素子の各層について詳述する。

#### 〔1〕電極

本発明の有機EL素子において、2つの電極のうち少なくとも一方は光透過性である。一般に光を透過させることのできる電極を「透明電極」と称するが、本発明において光を透過する電極は可視光領域全体において光透過率が高い必要はないので、以下本発明ではこのような電極を「EL透過電極」と称する。本発明のEL透過電極は有機EL素子の発光スペクトルの波長域について光透過率が高くなければならない。具体的には、EL透過電極の光透過率のピーク波長 $\lambda_T$ は有機EL素子の発光スペクトルのピーク波長を $\lambda_{EL}$ とすると、 $\lambda_{EL} \pm 100\text{nm}$ の範囲にあるのが好ましく、 $\lambda_{EL} \pm 50\text{nm}$ の範囲にあるのがより好ましく、 $\lambda_{EL} \pm 20\text{nm}$ の範囲にあるのが特に好ましい。

【0013】また、本発明のEL透過電極は可視光領域全体において光透過率が高い必要はない。優れたパワー効率を示す有機EL素子を得るためには、EL透過電極の光透過率のピークの半値幅は1nm以上350nm以下であるのが好ましく、1nm以上300nm以下であるのがより好ましく、1nm以上150nm以下であるのが特に好ましい。

【0014】EL透過電極の表面抵抗を低く抑えることで、有機EL素子の発光効率を上げることができる。EL透過電極の表面抵抗は好ましくは $15\Omega/\square$ 以下、より好ましくは $5\Omega/\square$ 以下、特に好ましくは $1\Omega/\square$ 以下、最も好ましくは $0.1\Omega/\square$ 以下である。表面抵抗を低く抑えるために、EL透過電極を2種以上の材料を用いた多層薄膜構造とするのが好ましく、3種以上の材料を用いた多層薄膜構造とするのがより好ましい。前記材料は電極として用いることができるものであれば何でもよく、ITO、酸化インジウム、酸化スズ又は酸化インジウム酸化亜鉛合金が好ましい。金、白金、銀マグネシウム等の金属薄膜を用いてもよい。ポリアニリン、ポリチオフェン、ポリピロール、それらの誘導体等の有機材料も使用可能である。

【0015】陽極をEL透過電極とした場合、陰極には仕事関数の低いLi、K等のアルカリ金属やMg、Ca等のアルカリ土類金属を用いるのが、電子注入性の観点から好ま

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しい。また、安定なAl等を用いるのも好ましい。安定性と電子注入性を両立させるために2種以上の材料を含む層にしてもよく、それらの材料については特開平2-15595、特開平5-121172等に記載されている。一方、陰極をEL透過電極とした場合、陽極にはITO、酸化スズ、酸化亜鉛酸化インジウム等のよく知られている材料を用いてよい。しかし、この場合陽極は光透過性である必要はないので、どのような導電性材料を用いてもよく、金や白金等の仕事関数が高い材料を用いるのが好ましい。

【0016】陽極、陰極等が無機層である場合、真空蒸着法、スパッタ法、イオンプレーティング法等の公知の方法で形成できる。また、電極 (特にEL透過電極) のパターンニングは、フォトリソグラフィ等による化学的エッチング、レーザー等を用いた物理的エッチング等により行うのが好ましい。また、マスクを重ねて真空蒸着やスパッタリング等を行なってパターンニングしてもよい。

#### 【0017】〔2〕発光層

本発明の有機発光素子に使用する発光層は、電子輸送性であってもホール輸送性であってもよい。発光層は少なくとも一種の発光材料を含有する。発光材料は励起されて蛍光を発することのできるものであればよく、例えばオキシノイド化合物、ペリレン化合物、クマリン化合物、アザクマリン化合物、オキサゾール化合物、オキサジアゾール化合物、ペリノン化合物、ピロロピロール化合物、ナフタレン化合物、アントラセン化合物、フルオレン化合物、フルオランテン化合物、テトラセン化合物、ピレン化合物、コロネン化合物、キノロン化合物及びアザキノロン化合物、ピラゾリン誘導体及びピラゾロン誘導体、ローダミン化合物、クリセン化合物、フェナントレン化合物、シクロペンタジエン化合物、スチルベン化合物、ジフェニルキノン化合物、スチリル化合物、ジスチリルベンゼン化合物、ブタジエン化合物、ジシアノメチレンピラン化合物、ジシアノメチレンチオピラン化合物、フルオレセイン化合物、ピリリウム化合物、チアピリリウム化合物、セナピリリウム化合物、テルロピリリウム化合物、芳香族アルダジエン化合物、オリゴフェニレン化合物、キサンテン化合物及びチオキサンテン化合物、シアニン化合物、アクリジン化合物、アクリドン化合物、キノリン化合物、8-ヒドロキシキノリン化合物の金属錯体、ベンゾキノリノールベリリウム錯体、2,2'-ビピリジン化合物の金属錯体、シッフ塩基とIII族金属との錯体、オキサジアゾール化合物の金属錯体、希土類錯体等が使用可能である。

【0018】これらの発光材料は単独で用いても複数併用してもよい。また、キャリア輸送性の高分子中に分子分散させるか、或いは低分子キャリア輸送剤と発光材料をキャリア輸送性のない高分子中に分子分散させて使用してもよい。ここで、低分子キャリア輸送剤とは電子輸送性 (電子受容性) 又はホール輸送性 (電子供与性) の低分子材料をいい、キャリア輸送性のない高分子とはポ

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リメチルメタクリレート、ポリメチルアクリレート、ポリスチレン、ポリカーボネート等のような電気的に不活性な高分子をいう。

【0019】発光層に高分子発光材料を用いることも好ましい。高分子発光材料の例としては、ポリ-p-フェニレンビニレン誘導体、ポリフルオレン誘導体、ポリチオフェン誘導体等のπ共役系高分子や、低分子色素、テトラフェニルジアミン、トリフェニルアミン等を主鎖や側鎖に導入した高分子等が挙げられる。高分子発光材料に低分子発光材料を混合して使用してもよい。

#### 【0020】〔3〕基板

本発明において、透明基板として通常のガラス基板の他にプラスチック基板を使用することができる。基板として用いるプラスチックは耐熱性、寸法安定性、耐溶剤性、電気絶縁性、加工性、低通気性及び低吸湿性に優れていることが必要である。このようなプラスチックとしては、ポリエチレンテレフタレート、ポリブチレンテレフタレート、ポリエチレンナフタレート、ポリスチレン、ポリカーボネート、ポリエーテルスルホン、ポリアリレート、アリルジグリコールカーボネート、ポリイミド等が挙げられる。

【0021】基板の電極側の面、電極と反対側の面、又はその両方に透湿防止層（ガスバリア層）を設置するのが好ましい。透湿防止層を構成する材料としては窒化ケイ素や酸化ケイ素等の無機物が好ましい。透湿防止層は高周波スパッタリング法等により成膜できる。また、必要に応じてハードコート層やアンダーコート層を設けてもよい。

#### 【0022】〔4〕ホール輸送層

ホール輸送層を形成するホール輸送性化合物としては、ポリ-N-ビニルカルバゾール誘導体、ポリフェニレンビニレン誘導体、ポリフェニレン、ポリチオフェン、ポリメチルフェニルシラン、ポリアニリン、トリアゾール誘導体、オキサジアゾール誘導体、イミダゾール誘導体、ポリアリーラルカン誘導体、ピラゾリン誘導体、ピラゾロン誘導体、フェニレンジアミン誘導体、アリーラルアミン誘導体、アミノ置換カルコン誘導体、オキサゾール誘導体、カルバゾール誘導体、スチリルアントラセン誘導体、フルオレノン誘導体、ヒドラゾン誘導体、スチルベン誘導体、ポリフィリン誘導体（フタロシアニン等）、芳香族三級アミン化合物、スチリルアミン化合物、ブタジエン化合物、ベンジジン誘導体、ポリスチレン誘導体、トリフェニルメタン誘導体、テトラフェニルベンジン誘導体、スターバーストポリアミン誘導体等が使用可能である。

#### 【0023】〔5〕電子輸送層

電子輸送層を形成する電子輸送性化合物としては、オキサジアゾール誘導体、トリアゾール誘導体、トリアジン誘導体、ニトロ置換フルオレノン誘導体、チオピランジ

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オキサゾール誘導体、ジフェニルキノン誘導体、ペリレン誘導体、テトラカルボキシル誘導体、アントラキノジメタン誘導体、フレオレニリデンメタン誘導体、アントロン誘導体、ベリノン誘導体、オキシシン誘導体、キノリン錯体誘導体等が挙げられる。電子輸送層の上に陰極を設けるが、それらの間に酸化アルミニウム、フッ化リチウム等の薄層（0.01~10nm程度）を挟んでもよい。

#### 【0024】〔6〕導電性高分子層

導電性高分子層を形成する導電性高分子としては、W098/05187等に記載のポリアニリン誘導体、ポリチオフェン誘導体及びポリピロール誘導体が好ましい。これらはプロトン酸（例えば、樟脳スルホン酸、p-トルエンスルホン酸、スチレンスルホン酸、ポリスチレンスルホン酸等）と混合した状態で使用してもよく、必要に応じて他の高分子（ポリメチルメタクリレート（PMMA）、ポリ-N-ビニルカルバゾール（PVCz）等）と混合して使用してもよい。導電性高分子層の表面抵抗は10000Ω/□以下であるのが好ましく、膜厚は好ましくは10nm~1000nmであり、より好ましくは20nm~200nmである。

#### 【0025】〔7〕その他の層

湿気や空気を遮断するために、陰極の表面（有機層と反対側の面）に特開平7-85974号等に記載の保護層を形成してもよい。更に、ガラスやポリ（クロロトリフルオロエチレン）シートを用いて封止することが好ましい。この中に乾燥剤や撥水性のフッ素系不活性液体等を挿入してもよい。

【0026】また、有機EL素子には一般に水分や酸素の侵入を防止するための封止層を設ける。封止層を形成する封止材料としては、テトラフルオロエチレンと少なくとも1種のモノマーとの共重合体、共重合主鎖に環状構造を有する含フッ素共重合体、ポリエチレン、ポリプロピレン、ポリメチルメタクリレート、ポリイミド、ポリユリア、ポリテトラフルオロエチレン、ポリクロロトリフルオロエチレン、ポリジクロロジフルオロエチレン、クロロトリフルオロエチレンとジクロロジフルオロエチレンの共重合体、吸水率1%以上の吸水性物質と吸水率0.1%以下の防湿性物質の混合物、金属（In、Sn、Pb、Au、Cu、Ag、Al、Ti、Ni等）、金属酸化物（MgO、SiO、SiO<sub>2</sub>、Al<sub>2</sub>O<sub>3</sub>、GeO、NiO、CaO、BaO、Fe<sub>2</sub>O<sub>3</sub>、Y<sub>2</sub>O<sub>3</sub>、TiO<sub>2</sub>等）、金属フッ化物（MgF<sub>2</sub>、LiF、AlF<sub>3</sub>、CaF<sub>2</sub>等）、液状フッ素化炭素（パーフルオロアルカン、パーフルオロアミン、パーフルオロエーテル等）、等該液状フッ素化炭素に水分や酸素を吸着する吸着剤を分散させたもの等が使用可能である。

#### 【0027】

【実施例】本発明の有機EL素子において陽極及び陰極のどちらが光透過性であっても基本的に得られる効果は同じであるので、以下、光透過性の陽極を有する有機EL素子について実施例により詳述する。

#### 【0028】比較例1

50 50mm角のガラス基板をアセトン、セミコクリーン、イソ

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プロピルアルコール (IPA) で超音波洗浄し、次いでIPA煮沸洗浄し、更にUV/O<sub>3</sub>洗浄を行った。そのガラス基板をスパッタ室に移動し、ガラス基板にITOを厚み0.2 $\mu$ mでスパッタし、フォトリソグラフィによって図1のようにパターンニングして陽極とした。この陽極の表面抵抗を4端子法により測定した結果、20 $\Omega$ /□であった。陽極の光透過率を測定した結果を図3に実線で示す。

【0029】得られたITO基板に、ホール輸送層としてN,N'-ビス (3-メチルフェニル) - (1,1'-ピフェニル) - 4,4'-ジアミン (TPD) を、蒸着速度3~4 $\text{\AA}$ /秒で厚み400 $\text{\AA}$ となるように蒸着し、次に発光層としてトリス (8-キノリノラト) アルミニウム (Alq) を蒸着速度3~6 $\text{\AA}$ /秒で厚み600 $\text{\AA}$ となるように蒸着した。更にその上にマスクを用いて図2に示すようにMg/Ag合金 (モル比Mg/Ag=10:1) の陰極を厚み0.6 $\mu$ mとなるように蒸着し、この陰極上にAgを0.5 $\mu$ mの厚みで蒸着し、有機EL素子を形成した。この有機EL素子の発光スペクトルを測定した結果を図3に一点破線で示す。

#### 【0030】比較例2

ITOを厚み0.1 $\mu$ mでスパッタすること以外は比較例1と同様に有機EL素子を形成した。陽極の表面抵抗は42.0 $\Omega$ /□であった。この陽極の光透過率 (実線) 及び得られた有機EL素子の発光スペクトル (一点破線) を図4に示す。

#### 【0031】実施例1

ITO上に金を厚み4nmで蒸着し、その上に更にITOを厚み0.2 $\mu$ mでスパッタし、図1のようにパターンニングして陽極とすること以外は比較例1と同様に有機EL素子を形成した。この陽極の表面抵抗は14.0 $\Omega$ /□であった。陽極の光透過率 (実線) 及び得られた有機EL素子の発光スペクトル (一点破線) を図5に示す。

#### 【0032】実施例2

ITO上に金を厚み8nmで蒸着し、その上に更にITOを厚み0.2 $\mu$ mでスパッタし、図1のようにパターンニングして陽極とすること以外は比較例1と同様に有機EL素子を形成した。陽極の表面抵抗は4.1 $\Omega$ /□であった。この陽極の光透過率 (実線) 及び得られた有機EL素子の発光スペクトル (一点破線) を図6に示す。

#### 【0033】実施例3

ITO上に金を厚み12nmで蒸着し、その上に更にITOを厚み0.2 $\mu$ mでスパッタし、図1のようにパターンニングして陽極とすること以外は比較例1と同様に有機EL素子を形成した。陽極の表面抵抗は0.12 $\Omega$ /□であった。この陽極の光透過率 (実線) 及び得られた有機EL素子の発光スペクトル (一点破線) を図7に示す。

表1

	表面抵抗 ( $\Omega$ /□)	パワー効率 (lm/W)			
		10ms	100 $\mu$ s	1 $\mu$ s	10ns
比較例1	20.0	1.81	1.62	1.43	1.19
比較例2	42.0	1.45	1.22	1.09	0.81

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#### \* 【0034】実施例4

ITO上に金を厚み4nmで蒸着し、ITOを厚み0.1 $\mu$ mでスパッタし、金を厚み4nmで蒸着し、更にITOを厚み0.1 $\mu$ mでスパッタし、図1のようにパターンニングして陽極とすること以外は比較例1と同様に有機EL素子を形成した。この陽極の表面抵抗は4.8 $\Omega$ /□であった。陽極の光透過率 (実線) 及び得られた有機EL素子の発光スペクトル (一点破線) を図8に示す。

#### 【0035】実施例5

ITO上に金を厚み4nmで蒸着し、ITOを厚み0.1 $\mu$ mでスパッタし、金を厚み8nmで蒸着し、更にITOを厚み0.1 $\mu$ mでスパッタし、図1のようにパターンニングして陽極とすること以外は比較例1と同様に有機EL素子を形成した。この陽極の表面抵抗は0.14 $\Omega$ /□であった。陽極の光透過率 (実線) 及び得られた有機EL素子の発光スペクトル (一点破線) を図9に示す。

#### 【0036】実施例6

ITO上に金を厚み4nmで蒸着し、ITOを厚み0.1 $\mu$ mでスパッタし、白金を厚み8nmで蒸着し、更にITOを厚み0.1 $\mu$ mでスパッタし、図1のようにパターンニングして陽極とすること以外は比較例1と同様に有機EL素子を形成した。この陽極の表面抵抗は0.11 $\Omega$ /□であった。陽極の光透過率 (実線) 及び得られた有機EL素子の発光スペクトル (一点破線) を図10に示す。

#### 【0037】パワー効率の測定

本発明ではパワー効率は以下のように求めた。まず有機EL素子に印加する電圧を変えて輝度及び電流を測定し、それらの関係を示す検量線を作成した。なお、輝度は輝度計BM-5A (トプコン社製) を用いて測定し、電流はAPDモジュールC5460 (浜松フォトニクス製) を用いて検出した。次にファンクションジェネレーターSG4111 (岩崎通信機製) を用いて、輝度が約1000cd/m<sup>2</sup>となるように方形波で有機EL素子に電圧を印加し (1パルスの電圧印加時間10<sup>-9</sup>秒~10<sup>-3</sup>秒)、その時の発光量をAPDモジュールC5460にて検出し、流れる電流と同時にオシロスコープにて観測した。そのときの1パルス内の電流値から平均入力電力を計算し、APDモジュールC5460により1パルス内で検出した平均電流値と前記検量線から平均輝度を求め、パワー効率を求めた。

【0038】比較例1、2及び実施例1~6で形成した有機EL素子のパワー効率を上述のように求めた結果を、陽極の表面抵抗と併せて表1に示す。なお、表1中、10ms、100 $\mu$ s、1 $\mu$ s及び10nsは1パルスの電圧印加時間を表す。

#### 【0039】

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実施例 1	14.0	1.91	1.74	1.62	1.49
実施例 2	4.1	2.11	1.96	1.83	1.67
実施例 3	0.12	2.31	2.18	2.04	1.88
実施例 4	4.8	2.05	1.89	1.72	1.53
実施例 5	0.14	2.28	2.14	1.97	1.76
実施例 6	0.11	2.42	2.24	2.06	1.87

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【0040】表1より、比較例1及び2の有機EL素子と比較して、実施例1～6の有機EL素子は高いパワー効率を示すことがわかる。これは、実施例1～6は光透過率を全波長域にわたって高める必要がないために得られた効果であるといえる。また、その効果は電圧印加時間が短い条件下で特に顕著であることがわかる。

#### 【0041】比較例3

比較例1と同様に作成したITO基板上に、銅フタロシアニン厚み200Åとなるように蒸着し、TPD厚み600Åとなるように蒸着し、4,4'-ビス(2,2'-ジフェニルビニル)ピフェニル(DPVBi)を厚み400Åとなるように蒸着し、更にAlqを厚み200Åとなるように蒸着した。その上にマスクを用いて図2に示すようにMg/Ag合金(モル比Mg/Ag=10:1)の陰極を厚み0.6μmとなるように蒸着し、この陰極上にAgを0.5μmの厚みで蒸着し、有機EL素子を形成した。陽極の光透過率(実線)及び有機EL素子の発光スペクトル(一点破線)を図11に示す。

#### 【0042】実施例7

ITO上に銀を厚み8nmで蒸着し、その上に更にITOを厚み0.1μmでスパッタし、図1のようにパターンニングして陽極とすること以外は比較例3と同様に有機EL素子を形成した。この陽極の表面抵抗は0.10Ω/□であった。陽極の光透過率(実線)及び得られた有機EL素子の発光スペ

\*クトル(一点破線)を図12に示す。

#### 【0043】実施例8

ITO上に銀を厚み4nmで蒸着し、ITOを厚み0.1μmでスパッタし、銀を厚み4nmで蒸着し、更にITOを厚み0.1μmでスパッタし、図1のようにパターンニングして陽極とすること以外は比較例3と同様に有機EL素子を形成した。この陽極の表面抵抗は0.13Ω/□であった。陽極の光透過率(実線)及び得られた有機EL素子の発光スペクトル(一点破線)を図13に示す。

#### 【0044】実施例9

ITO上に白金を厚み4nmで蒸着し、ITOを厚み0.1μmでスパッタし、銀を厚み4nmで蒸着し、更にITOを厚み0.1μmでスパッタし、図1のようにパターンニングして陽極とすること以外は比較例3と同様に有機EL素子を形成した。この陽極の表面抵抗は0.15Ω/□であった。陽極の光透過率(実線)及び得られた有機EL素子の発光スペクトル(一点破線)を図14に示す。

【0045】比較例3及び実施例7～9で形成した有機EL素子のパワー効率を上述のように求めた結果を、陽極の表面抵抗と併せて表2に示す。なお、表2中、10ms、100μs、1μs及び10nsは1パルスの電圧印加時間を表す。

#### 【0046】

表2

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	表面抵抗 (Ω/□)	10ms	100μs	1μs	10ns
比較例3	20.0	1.32	1.11	0.90	0.73
実施例7	0.10	1.44	1.25	1.14	1.04
実施例8	0.13	1.52	1.36	1.24	1.11
実施例9	0.15	1.55	1.38	1.26	1.14

【0047】表2より、比較例3の有機EL素子と比較して、実施例7～9の有機EL素子は高いパワー効率を示すことがわかる。これは、実施例7～9は光透過率を全波長域にわたって高める必要がないために得られた効果であるといえる。また、その効果は電圧印加時間が短い条件下で特に顕著であることがわかる。

#### 【0048】

【発明の効果】以上詳述したように、本発明の有機EL素子は表面抵抗の低い光透過性の電極を有し、高いパワー効率を示す。

#### 【図面の簡単な説明】

【図1】 本発明の有機EL素子の、陽極のパターン例を示す概略図である。

【図2】 本発明の有機EL素子の、陽極及び陰極のパタ

ーン例を示す概略図である。

【図3】 比較例1の有機EL素子の発光スペクトル(一点破線)及び陽極の光透過率(実線)を示すグラフである。

【図4】 比較例2の有機EL素子の発光スペクトル(一点破線)及び陽極の光透過率(実線)を示すグラフである。

【図5】 実施例1の有機EL素子の発光スペクトル(一点破線)及び陽極の光透過率(実線)を示すグラフである。

【図6】 実施例2の有機EL素子の発光スペクトル(一点破線)及び陽極の光透過率(実線)を示すグラフである。

【図7】 実施例3の有機EL素子の発光スペクトル(一

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点破線) 及び陽極の光透過率(実線)を示すグラフである。

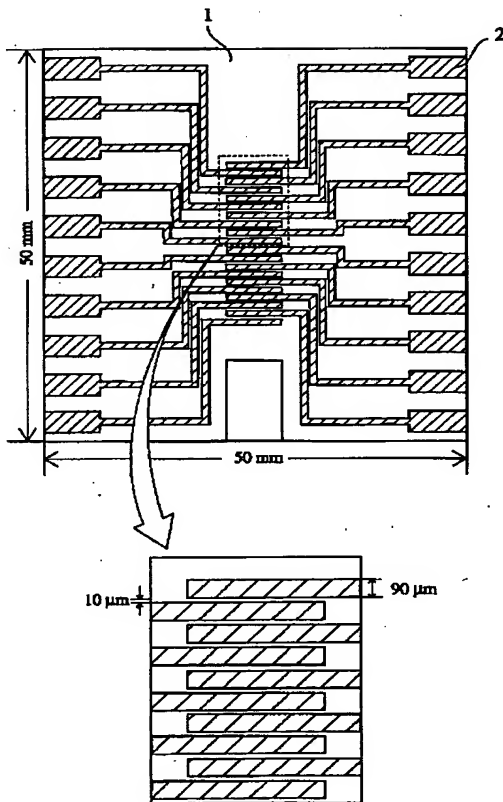
【図8】 実施例4の有機EL素子の発光スペクトル(一点破線) 及び陽極の光透過率(実線)を示すグラフである。

【図9】 実施例5の有機EL素子の発光スペクトル(一点破線) 及び陽極の光透過率(実線)を示すグラフである。

【図10】 実施例6の有機EL素子の発光スペクトル(一点破線) 及び陽極の光透過率(実線)を示すグラフである。

【図11】 比較例3の有機EL素子の発光スペクトル(一点破線) 及び陽極の光透過率(実線)を示すグラフである。

【図1】



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【図12】 実施例7の有機EL素子の発光スペクトル(一点破線) 及び陽極の光透過率(実線)を示すグラフである。

【図13】 実施例8の有機EL素子の発光スペクトル(一点破線) 及び陽極の光透過率(実線)を示すグラフである。

【図14】 実施例9の有機EL素子の発光スペクトル(一点破線) 及び陽極の光透過率(実線)を示すグラフである。

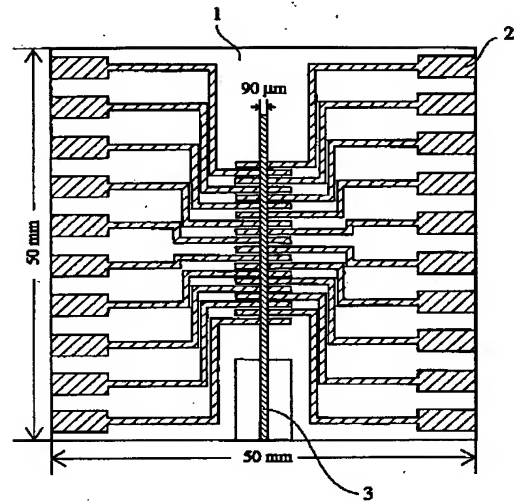
【符号の説明】

1・・・基板

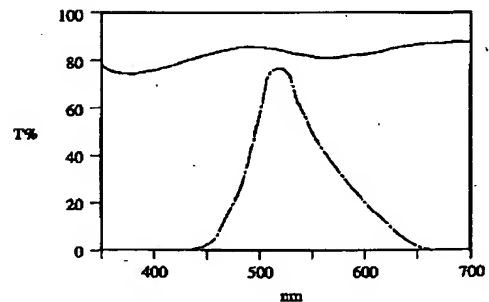
2・・・陽極

3・・・陰極

【図2】

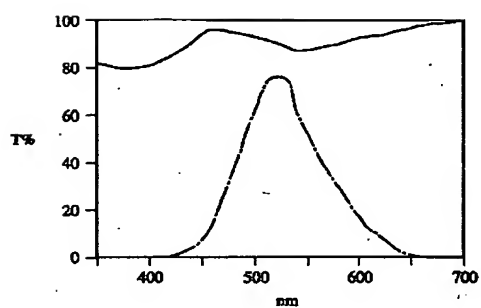


【図3】

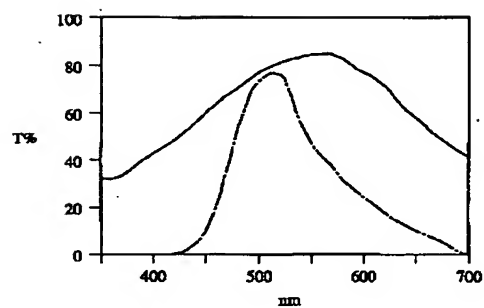


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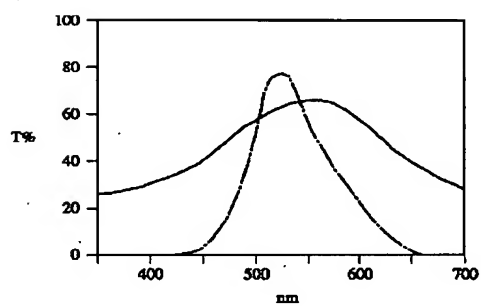
【図4】



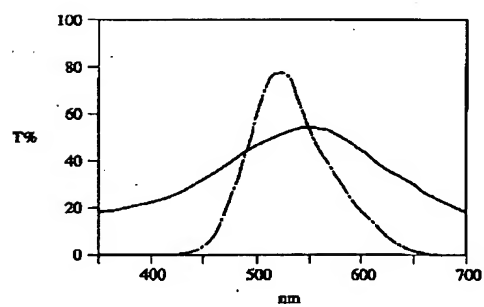
【図5】



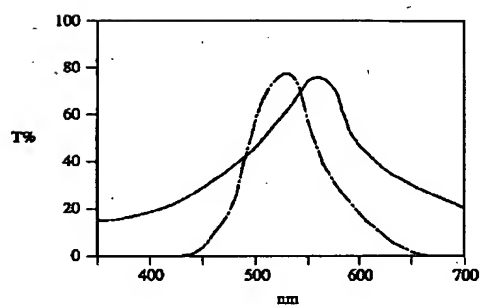
【図6】



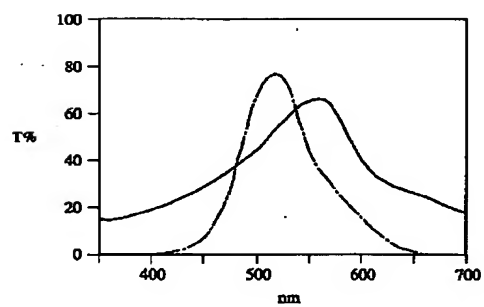
【図7】



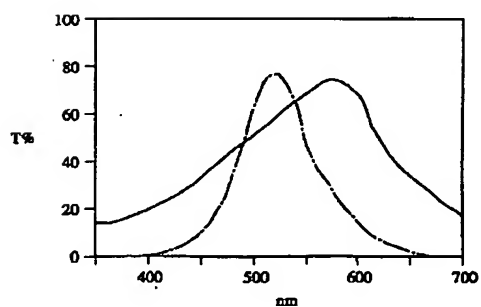
【図8】



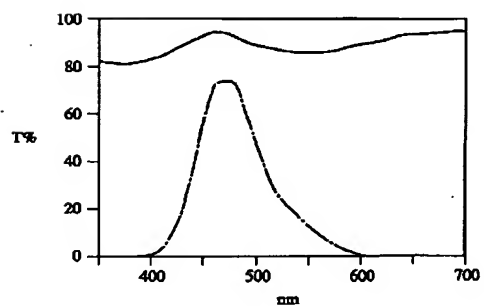
【図9】



【図10】



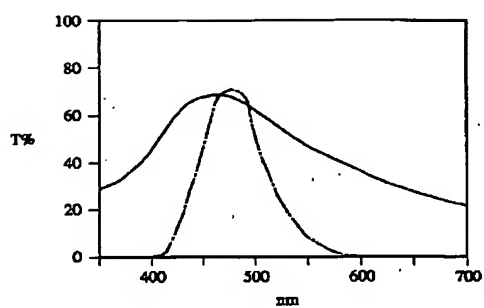
【図11】



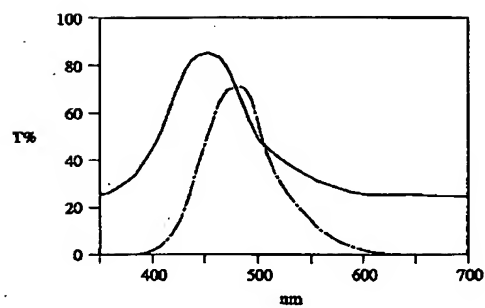


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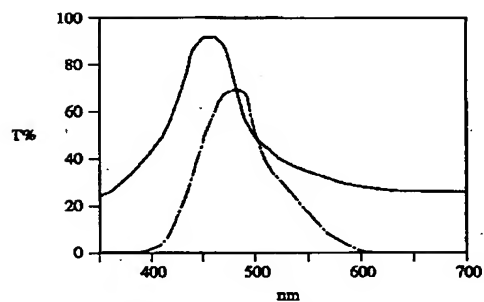
【図12】



【図13】



【図14】



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フロントページの続き

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(71)Applicant : FUJI PHOTO FILM CO LTD  
FUJI PHOTO OPTICAL CO LTD

(22)Date of filing : 16.07.1999

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OKANIWA MASAYUKI

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## (54) ORGANIC ELECTROLUMINESCENCE ELEMENT

### (57)Abstract:

**PROBLEM TO BE SOLVED:** To enhance power efficiency by setting a peak value and a peak half-breadth value of light transmittance of at least one translucent electrode of two electrodes between which at least one organic layer is interposed in a specified range.

**SOLUTION:** Light transmittance of at least one translucent electrode of an anode and a cathode between which a luminescent layer and a hole transport layer or an electron transport layer are interposed has a peak value of an emission spectrum peak wavelength  $\pm 100$  nm and a peak half breadth of 1-350 nm, and high light-transmittance in a visual light whole region is made unnecessary. The surface resistance of this electrode is limited to 15  $\Omega$ /m<sup>2</sup> or less, and this electrode is preferably formed in a multi-layer made of materials of at least two kinds or at least three kinds mainly comprising ITO, indium oxide, tin oxide, or indium oxide zinc oxide composite, and power efficiency is furthermore enhanced. Emission of the element in a pulse width of 10<sup>-9</sup>-10<sup>-3</sup> second is preferable. Installation of a conductive polymer layer coming in contact with the anode is allowable, and the organic layer film can be made thick without increasing driving voltage.

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**CLAIMS**

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[Claim(s)]

[Claim 1] They are the organic electroluminescence devices to which it has at least one organic layer in inter-electrode [ two ], at least one of the two aforementioned electrodes has the peak value of the light transmittance of the electrode of the aforementioned light-transmission nature in the range of \*\*100nm of peak wavelengths of an emission spectrum in the organic electroluminescence devices which are the electrodes of light-transmission nature, and the full width at half maximum of the aforementioned light transmittance is characterized by 1nm or more being 350nm or less.

[Claim 2] They are the organic electroluminescence devices characterized by the surface electrical resistance of the electrode of the aforementioned light-transmission nature being below 15ohms / \*\* in organic electroluminescence devices according to claim 1.

[Claim 3] They are the organic electroluminescence devices characterized by being the multilayered film which the electrode of the aforementioned light-transmission nature becomes from two or more sorts of material in organic electroluminescence devices according to claim 1 or 2.

[Claim 4] They are the organic electroluminescence devices characterized by being the multilayered film which the electrode of the aforementioned light-transmission nature becomes from three or more sorts of material in organic electroluminescence devices according to claim 3.

[Claim 5] The electrodes of the aforementioned light-transmission nature are organic electroluminescence devices to which it is characterized by principal components being either ITO, indium oxide, the tin oxide and an indium oxide zinc-oxide alloy in organic electroluminescence devices according to claim 1 to 4.

[Claim 6] Organic electroluminescence devices characterized by emitting light by the pulse width for 10-9 - 10 to 3 seconds in organic electroluminescence devices according to claim 1 to 5.

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**DETAILED DESCRIPTION**

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[Detailed Description of the Invention]

[0001]

[The technical field to which invention belongs] this invention relates to the organic electroluminescence devices which show high power efficiency.

[0002]

[Description of the Prior Art] Since it can form as a field light emitting device comparatively easily using a vacuum deposition or the applying method, promising \*\* of the organic electroluminescence devices (an organic EL element is called hereafter) is carried out very much as an object for flat-panel displays. In recent years, the organic EL element is studied briskly and the organic EL element which has the outstanding performance which is equal to inorganic [ Light Emitting Diode ] has been developed.

[0003] Since an organic EL element is a field light emitting device, usually, between two electrodes, to one side, resistance is low and what has a high light transmittance is used. Although the electrode which consists of ITO by which tin was doped by indium oxide, for example as such an electrode is known well (JP,11-67460,A), development of the organic EL element which shows the further excellent power efficiency is desired by using the electrode to which resistance penetrates light effectively low further rather than this, and this electrode.

[0004]

[Problem(s) to be Solved by the Invention] The purpose of this invention is offering the organic EL element which shows high power efficiency.

[0005]

[Means for Solving the Problem] In view of the above-mentioned purpose, wholeheartedly, this invention persons were the electrodes of light-transmission nature at least one of two electrodes as a result of research, and the peak value of the light transmittance is in the range of \*\*100nm of peak wavelengths of an emission spectrum, and the full width at half maximum of the aforementioned light transmittance discovered that high power efficiency was shown, and hit on an idea of organic 1nm or more EL element which is 350nm or less to this invention.

[0006] Moreover, the organic EL element of this invention shows the further excellent power efficiency by fulfilling the desirable conditions of (1) - (4) below.

(1) As for the surface electrical resistance of the electrode of light-transmission nature, it is desirable that they are below 15ohms / \*\*.

(2) As for the electrode of light-transmission nature, it is desirable that it is the multilayered film which consists of two or more sorts of material, and it is more desirable that it is the multilayered film which consists of three or more sorts of material.

(3) As for the electrode of light-transmission nature, it is desirable that principal components are either ITO, indium oxide, the tin oxide and an indium oxide zinc-oxide alloy.

(4) As for an organic EL element, it is desirable to emit light by the pulse width for 10<sup>-9</sup> - 10 to 3 seconds.

[0007]

[Embodiments of the Invention] Fundamentally, the organic EL element of this invention carries out the laminating of an anode plate, the hole transporting bed which it is arbitrary and is prepared, a luminous layer, the electronic transporting bed which it is arbitrary and is prepared, and the cathode on a substrate

at order, constitutes, and has at least one organic layer in inter-electrode [ two ], and at least one side is light-transmission nature between two electrodes. Specifically, the composition which consists of an anode plate / a luminous layer / cathode, the composition which consists of an anode plate / hole transporting bed / a luminous layer / cathode, the composition which consists of an anode plate / luminous layer / an electronic transporting bed / cathode, the composition which consists of an anode plate / hole transporting bed / luminous layer / an electronic transporting bed / cathode are possible. Moreover, the composition which carried out the laminating of these conversely on the substrate is also possible.

Furthermore, a luminous layer, a hole transporting bed, or a two or more layers electronic transporting bed may be prepared, or a hole pouring layer and an electron-injection layer may be prepared.

[0008] Furthermore by this invention, you may install a conductive polymer layer in contact with an anode plate. By installing a conductive polymer layer, the film of an organic layer can be thickened without driver voltage almost going up, and brightness nonuniformity and short generating can be suppressed.

[0009] The organic EL element which has minute optical-resonator structure (micro cavity) in addition to the above composition has the small half-value width of an emission spectrum, and is desirable at a point excellent in directivity. The organic EL element which has minute optical-resonator structure as indicated by the "organic EL display" (techno Times company) 105 page of for example, a "monthly display" October, 1998 issue separate volume Using a transparent substrate as a substrate, on this, it comes to carry out the laminating of the back plate (cathode) which has the role of a dielectric mirror, a transparent electrode (anode plate), at least one-layer organic layer, and a metal mirror in order, and a minute optical resonator is formed between a dielectric mirror and a back plate. A dielectric mirror usually carries out the laminating of  $1/4$  wave of  $\text{SiO}_2$  and  $\text{TiO}_2$  by turns.  $\text{SiO}_2$  spacer may be introduced between transparent electrodes (ITO etc.) and a dielectric mirror, and thickness may be adjusted to it.

[0010] An organic layer can be formed using well-known methods, such as a vacuum deposition method, a sputter, a dipping method, the spin coating method, the casting method, the bar coat method, and the roll coat method. Moreover, a multilayer application is also possible by using a solvent properly.

[0011] Although the organic EL element of this invention can also use a single pixel, it is preferably used according to the luminescent color as a two or more successive installation \*\*\*\*\* dot array. Each luminescent color in at least one line may be two or more lines. 10-500 micrometers of sizes of 1 pixel are 50-300 micrometers preferably.

[0012] Hereafter, each class of the organic EL element of this invention is explained in full detail.

[1] In the organic EL element of an electrode this invention, at least one side is light-transmission nature between two electrodes. Although the electrode which can make light penetrate generally is called a "transparent electrode", since the light transmittance does not need to be high in the whole light field, the electrode which penetrates light in this invention calls such an electrode "EL transparency electrode" by this invention below. EL transparency electrode of this invention must have a high light transmittance about the wavelength region of the emission spectrum of an organic EL element. When peak-wavelength  $\lambda_T$  of the light transmittance of EL transparency electrode specifically sets peak wavelength of the emission spectrum of an organic EL element to  $\lambda_{EL}$ , it is desirable that it is in the range of  $\lambda_{EL} \times 100\text{nm}$ , it is more desirable that it is in the range which is  $\lambda_{EL} \times 50\text{nm}$ , and it is desirable that it is especially in the range which is  $\lambda_{EL} \times 20\text{nm}$ .

[0013] Moreover, EL transparency electrode of this invention does not need to have a high light transmittance in the whole light field. In order to obtain the organic EL element which shows the outstanding power efficiency, it is desirable that it is [ 1nm or more ] 350nm or less, as for the full width at half maximum of the light transmittance of EL transparency electrode, it is more desirable that it is [ 1nm or more ] 300nm or less, and it is desirable that it is [ 1nm or more ] especially 150nm or less.

[0014] The luminous efficiency of an organic EL element can be raised by stopping the surface electrical resistance of EL transparency electrode low. The surface electrical resistance of EL transparency electrode is below 0.1ohms / \*\* most preferably below 1ohm / \*\* especially preferably below 5ohms / \*\* more preferably [ below 15ohms / \*\* ] preferably. In order to stop surface electrical resistance low, it is desirable to make EL transparency electrode into the multilayered-film structure which used two or more

sorts of material, and it is more desirable to consider as the multilayered-film structure using three or more sorts of material. If it can use as an electrode, the aforementioned material is good anything and ITO, indium oxide, tin oxide, or its indium oxide zinc-oxide alloy is desirable. You may use metal thin films, such as gold, platinum, and silver magnesium. Organic materials, such as the poly aniline, the poly thiophene, polypyrrole, and those derivatives, are also usable.

[0015] When an anode plate is used as EL transparency electrode, it is desirable from a viewpoint of electron-injection nature to use alkaline earth metal, such as alkali metal, such as Li with a low work function and K, and Mg, calcium, for cathode. Moreover, it is also desirable to use stable aluminum etc. In order to reconcile stability and electron-injection nature, it may be made the layer containing two or more sorts of material, and those material is indicated by JP,2-15595,A, JP,5-121172,A, etc. On the other hand, when cathode is used as EL transparency electrode, you may use a material good [ ITO, tin oxide, and / zinc-oxide ] and known for an anode plate. However, it is desirable to use what conductive material and to use material with the large work function of gold, platinum, etc. in this case, since an anode plate does not need to be light-transmission nature.

[0016] When an anode plate, cathode, etc. are inorganic layers, it can form by well-known methods, such as a vacuum deposition method, a spatter, and the ion plating method. Moreover, as for patterning of an electrode (especially EL transparency electrode), it is desirable that physical etching using the chemical etching by photo lithography etc., laser, etc. performs. Moreover, in piles, vacuum deposition, sputtering, etc. may be performed and patterning of the mask may be carried out.

[0017] [2] Even if the luminous layer used for the organic light emitting device of a luminous layer this invention is electronic transportability, it may be hole transportability. A luminous layer contains a kind of luminescent material at least. That luminescent material should just be what is excited and can emit fluorescence For example, an oxy-NOIDO compound, a perylene compound, a coumarin compound, an AZAKU marine compound, An oxazole compound, an OKISA diazole compound, a peri non compound, a pyrrolo pyrrole compound, A naphthalene compound, an anthracene compound, a fluorene compound, a fluoranthene compound, A tetracene compound, a pyrene compound, a coronene compound, a quinolone compound, and an AZAKINORON compound, A pyrazoline derivative and a pyrazolone derivative, a rhodamine compound, a chrysene compound, A phenanthrene compound, a cyclopentadiene compound, a stilbene compound, A diphenyl quinone compound, a styryl compound, JISUCHIRIRU benzenoid, A butadiene compound, a dicyanomethylene pyran compound, a dicyanomethylene thiopyran compound, A fluorescein compound, a pyrylium compound, a thia pyrylium compound, A SERENA pyrylium compound, a TERURO pyrylium compound, an aromatic ARUDA diene compound, An oligo phenylene compound, a xanthene compound, and a thioxan ten compound, A cyanine compound, an acridine compound, an acridone compound, a quinoline compound, The metal complex of a metal complex [ of 8-hydroxyquinoline compound ], benzo quinolinol beryllium complex, 2, and 2'-bipyridine compound, the complex of a Schiff base and an III group metal, the metal complex of an OKISA diazole compound, a rare earth complex, etc. are usable.

[0018] Even if it uses independently, you may use together two or more such luminescent material. Moreover, a molecular dispersion may be carried out into the macromolecule of carrier transportability, or the molecular dispersion of a low-molecular carrier transportation agent and the luminescent material may be carried out into a macromolecule without carrier transportability, and you may use it. here, as for a low-molecular carrier transportation agent, the macromolecule which says the low-molecular material of electronic transportability (electronic receptiveness) or hole transportability (electron-donative), and does not have carrier transportability needs a polymethylmethacrylate, poly methyl acrylate, polystyrene, a polycarbonate, etc. -- an inactive macromolecule is said electrically

[0019] It is also desirable to use macromolecule luminescent material for a luminous layer. As an example of macromolecule luminescent material, the macromolecule which introduced pi conjugated-system macromolecules, such as a Polly p-phenylenevinylene derivative, the poly fluorene derivative, and the poly thiophene derivative, low-molecular coloring matter, a tetrapod phenyl diamine, a triphenylamine, etc. into the principal chain or the side chain is mentioned. You may mix and use low-molecular luminescent material

for macromolecule luminescent material.

[0020] [3] In a substrate this invention, the plastic plate other than the usual glass substrate can be used as a transparent substrate. The plastics used as a substrate needs to excel in thermal resistance, dimensional stability, solvent resistance, electric insulation, processability, low permeability, and low hygroscopicity. As such plastics, a polyethylene terephthalate, a polybutylene terephthalate, polyethylenenaphthalate, polystyrene, a polycarbonate, polyether sulphone, a polyarylate, allyl-compound diethylene glycol carbonate, a polyimide, etc. are mentioned.

[0021] It is desirable to install a moisture permeation prevention layer (gas barrier layer) in the field by the side of the electrode of a substrate, the field of an electrode and an opposite side, or its both. As a material which constitutes a moisture permeation prevention layer, inorganic substances, such as silicon nitride and silicon oxide, are desirable. A moisture permeation prevention layer can be formed by the RF-sputtering method etc. Moreover, you may prepare a hard-coat layer and a under-coat layer if needed.

[0022] [4] As a hole transportability compound which forms a hole transporting-bed hole transporting bed A Polly N-vinylcarbazole derivative, a polyphenylene vinylene derivative, A polyphenylene, the poly thiophene, a poly methylphenyl silane, the poly aniline, A triazole derivative, an OKISA diazole derivative, an imidazole derivative, The poly aryl alkane derivative, a pyrazoline derivative, a pyrazolone derivative, A phenylenediamine derivative, an arylamine derivative, an amino substitution chalcone derivative, An oxazole derivative, a carbazole derivative, a styryl anthracene derivative, full -- me -- non -- a derivative, a hydrazone derivative, a stilbene derivative, and porphyrin derivatives (phthalocyanine etc.) -- The third class amine compound of aromatic series, a styryl amine compound, a butadiene compound, a benzidine derivative, a polystyrene derivative, a triphenylmethane-color derivative, a tetrapod phenyl benzene derivative, a starburst polyamine derivative, etc. are usable.

[0023] [5] as the electronic transportability compound which forms an electronic transporting-bed electronic transporting bed -- an OKISA diazole derivative, a triazole derivative, a triazine derivative, and nitration full -- me -- non -- a derivative, a thiopyran dioxide derivative, a diphenyl quinone derivative, a perylene tetrapod carboxyl derivative, an anthra quinodimethan derivative, a deflection ORENIRIDEN methane derivative, an anthrone derivative, and a peri -- non, a derivative, an oxine derivative, a quinoline complex derivative, etc. are mentioned Although cathode is prepared on an electronic transporting bed, you may also insert thin layers (about 0.01-10nm), such as an aluminum oxide and lithium fluoride, among them.

[0024] [6] As a conductive polymer which forms a conductive polymer layer conductive polymer layer, the poly aniline derivative, the poly thiophene derivative, and a polypyrrole derivative given in WO98 / 05187 grades are desirable. These may be used in the state where it mixed with proton acids (for example, a camphor sulfonic acid, p-toluenesulfonic acid, a styrene sulfonic acid, polystyrene sulfonate, etc.), and they may use it if needed, mixing them with other macromolecules (a polymethylmethacrylate (PMMA), Polly N-vinylcarbazole (PVCz), etc.). As for the surface electrical resistance of a conductive polymer layer, it is desirable that they are below 10000ohms / \*\*, and thickness is 10nm - 1000nm preferably, and is 20nm - 200nm more preferably.

[0025] [7] In order to intercept other layer moisture and other air, you may form the protective layer of a publication in the front face (field of an organic layer and an opposite side) of cathode at JP,7-85974,A etc. Furthermore, closing using glass or the poly (chlorotrifluoroethylene) sheet is desirable. Into this, you may insert a drying agent, a water-repellent fluorine system inactive liquid, etc.

[0026] Moreover, the closure layer for generally preventing the invasion of moisture or oxygen is prepared in an organic EL element. As a closure material which forms a closure layer, the copolymer of a tetrafluoroethylene and at least one sort of comonomers, The fluorine-containing copolymer which has a cyclic structure in a copolymerization principal chain, polyethylene, polypropylene, A polymethylmethacrylate, a polyimide, a polyurea, a polytetrafluoroethylene, A polychlorotrifluoroethylene resin, poly dichlorodifluoroethene, The copolymer of a chlorotrifluoroethylene and dichlorodifluoroethene, The absorptivity matter of 1% or more of water absorptions, and the dampproof intermixing-of-material object of 0.1% or less of water absorptions, A metal (In, Sn, Pb, Au, Cu, Ag, aluminum, Ti, nickel, etc.), a metallic oxide (it GeO(s) and NiO(s) MgO, SiO, SiO2, and aluminum 2O3 --) CaO, BaO, Fe 2O3, Y2O3, TiO2



grade, and a metal fluoride (it LiF(s) MgF<sub>2</sub> --) The thing which made this liquefied fluoridation carbon, such as AlF<sub>3</sub>, CaF<sub>2</sub> grade, and liquefied fluoridation carbon (a perfluoro alkane, a perfluoro amine, perfluoro ether, etc.), distribute the adsorbent which adsorbs moisture and oxygen is usable.

[0027]

[Example] organic EL-element \*\*\*\* of this invention -- since the effect acquired fundamentally is the same even if which of an anode plate and cathode is light-transmission nature, the organic EL element which has the anode plate of light-transmission nature is hereafter explained in full detail according to an example

[0028] The glass substrate of 150mm angle of examples of comparison was cleaned ultrasonically by the acetone, the semi coculine, and isopropyl alcohol (IPA), subsequently IPA boiling washing was carried out, and UV/O<sub>3</sub> washing was performed further. The glass substrate was moved to the spatter room, and the spatter of the ITO was carried out to the glass substrate by the thickness of 0.2 micrometers, and by photo lithography, patterning was carried out like drawing 1 and it considered as the anode plate. As a result of measuring the surface electrical resistance of this anode plate by 4 terminal method, they were 20ohm/\*\*. A solid line shows the result which measured the light transmittance of an anode plate to drawing 3.

[0029] To the obtained ITO substrate, they are N and an N'-screw (3-methylphenyl) as a hole transporting bed. - (1 and 1'-biphenyl) The vacuum evaporatio of -4 and the 4'-diamine (TPD) was carried out so that it might become the thickness of 400A by the 3-4A evaporation rate, and next, as a luminous layer, tris (8-quinolinolato) aluminum (Alq) was deposited so that it might become the thickness of 600A by the 3-6 Furthermore, as a mask was used and it was shown on it at drawing 2, the vacuum evaporatio of the cathode of an Mg/Ag alloy (mole-ratio Mg/Ag=10:1) was carried out so that it might become the thickness of 0.6 micrometers, on this cathode, the vacuum evaporatio of Ag was carried out by the thickness of 0.5 micrometers, and the organic EL element was formed. An one-point dashed line shows the result which measured the emission spectrum of this organic EL element to drawing 3.

[0030] The organic EL element was formed like the example 1 of comparison except carrying out the spatter of the example of comparison 2ITO by the thickness of 0.1 micrometers. The surface electrical resistance of an anode plate was 42.0ohm/\*\*. The light transmittance (solid line) of this anode plate and the acquired emission spectrum (one-point dashed line) of an organic EL element are shown in drawing 4.

[0031] The organic EL element was formed like the example 1 of comparison except carrying out the vacuum evaporatio of the gold by the thickness of 4nm on example 1ITO, carrying out the spatter of the ITO by the thickness of 0.2 micrometers further on it, carrying out patterning like drawing 1, and considering as an anode plate. The surface electrical resistance of this anode plate was 14.0ohm/\*\*. The light transmittance (solid line) of an anode plate and the acquired emission spectrum (one-point dashed line) of an organic EL element are shown in drawing 5.

[0032] The organic EL element was formed like the example 1 of comparison except carrying out the vacuum evaporatio of the gold by the thickness of 8nm on example 2ITO, carrying out the spatter of the ITO by the thickness of 0.2 micrometers further on it, carrying out patterning like drawing 1, and considering as an anode plate. The surface electrical resistance of an anode plate was 4.1ohm/\*\*. The light transmittance (solid line) of this anode plate and the acquired emission spectrum (one-point dashed line) of an organic EL element are shown in drawing 6.

[0033] The organic EL element was formed like the example 1 of comparison except carrying out the vacuum evaporatio of the gold by the thickness of 12nm on example 3ITO, carrying out the spatter of the ITO by the thickness of 0.2 micrometers further on it, carrying out patterning like drawing 1, and considering as an anode plate. The surface electrical resistance of an anode plate was 0.12ohm/\*\*. The light transmittance (solid line) of this anode plate and the acquired emission spectrum (one-point dashed line) of an organic EL element are shown in drawing 7.

[0034] The organic EL element was formed like the example 1 of comparison except the vacuum evaporatio of the gold being carried out by the thickness of 4nm on example 4ITO, carrying out the spatter of the ITO by the thickness of 0.1 micrometers, carrying out the vacuum evaporatio of the gold

by the thickness of 4nm, carrying out the spatter of the ITO by the thickness of 0.1 micrometers further, carrying out patterning like drawing 1 , and considering as an anode plate. The surface electrical resistance of this anode plate was 4.8ohm/\*\*. The light transmittance (solid line) of an anode plate and the acquired emission spectrum (one-point dashed line) of an organic EL element are shown in drawing 8 .

[0035] The organic EL element was formed like the example 1 of comparison except the vacuum evaporations of the gold being carried out by the thickness of 4nm on example 5ITO, carrying out the spatter of the ITO by the thickness of 0.1 micrometers, carrying out the vacuum evaporations of the gold by the thickness of 8nm, carrying out the spatter of the ITO by the thickness of 0.1 micrometers further, carrying out patterning like drawing 1 , and considering as an anode plate. The surface electrical resistance of this anode plate was 0.14ohm/\*\*. The light transmittance (solid line) of an anode plate and the acquired emission spectrum (one-point dashed line) of an organic EL element are shown in drawing 9 .

[0036] The organic EL element was formed like the example 1 of comparison except the vacuum evaporations of the gold being carried out by the thickness of 4nm on example 6ITO, carrying out the spatter of the ITO by the thickness of 0.1 micrometers, carrying out the vacuum evaporations of the platinum by the thickness of 8nm, carrying out the spatter of the ITO by the thickness of 0.1 micrometers further, carrying out patterning like drawing 1 , and considering as an anode plate. The surface electrical resistance of this anode plate was 0.11ohm/\*\*. The light transmittance (solid line) of an anode plate and the acquired emission spectrum (one-point dashed line) of an organic EL element are shown in drawing 10 .

[0037] In the measurement this invention of power efficiency, power efficiency was searched for as follows. The voltage first impressed to an organic EL element was changed, brightness and current were measured, and the calibration curve which shows those relations was created. In addition, brightness was measured using luminance-meter BM-5A (TOPCON CORP. make), and current was detected using the APD module C5460 (product made from Hamamatsu photograph NIKUSU). Next, using the function generator SG4111 (Iwasaki Electric make), voltage was impressed to the organic EL element by the square wave so that brightness might serve as about 1000 cd/m<sup>2</sup> (10 to 9 seconds - voltage impression time 10 to 3 seconds of one pulse), and the amount of luminescence at that time was observed with the oscilloscope simultaneously with the current which detects and flows by the APD module C5460. Average input power was calculated from the current value within 1 pulse at that time, it asked for average luminance from the average current value detected within 1 pulse with the APD module C5460, and the aforementioned calibration curve, and power efficiency was searched for.

[0038] The result which searched for the power efficiency of the organic EL element formed in the examples 1 and 2 of comparison and the examples 1-6 as mentioned above is combined with the surface electrical resistance of an anode plate, and is shown in Table 1. In addition, the voltage impression time of one pulse is expressed for 10ms, 100 microseconds, 1 microsecond, and 10ns among Table 1.

[0039]

table 1 [ ] surface electrical resistance Power efficiency (lm/W)

(ohm/\*\*) 10ms 100 microseconds 1microsecond 10ns The example 1 of comparison 20.0 1.81 1.62 1.43 1.19 The example 2 of comparison 42.0 1.45 1.22 1.09 0.81 Example 1 14.0 1.91 1.74 1.62 1.49 Example 2 4.1 2.11 1.96 1.83 1.67 Example 3 0.12 2.31 2.18 2.04 1.88 Example 4 4.8 2.05 1.89 1.72 1.53 Example 50.14 2.28 2.14 1.97 1.76 Example 60.11 2.422.24 2.06 1.87 [0040] Table 1 shows that the organic EL element of examples 1-6 shows high power efficiency as compared with the organic EL element of the examples 1 and 2 of comparison. This can be said for examples 1-6 to be the effects acquired since it was not necessary to raise a light transmittance over a full wave length region. Moreover, it turns out that the effect is remarkable especially under the conditions that voltage impression time is short.

[0041] On the ITO substrate created like the example 1 of example of comparison 3 comparison, the vacuum evaporations of the copper phthalocyanine was carried out so that it might become the thickness of 200A, the vacuum evaporations of the TPD was carried out so that it might become the thickness of 600A, the vacuum evaporations of the 4 and 4'-screw (2 and 2'-diphenyl vinyl) biphenyl (DPVBi) was carried out so that it might become the thickness of 400A, and further, Alq was deposited so that it might become the thickness of 200A As a mask was used on it and it was shown in drawing 2 , the vacuum

evaporation of the cathode of an Mg/Ag alloy (mole-ratio Mg/Ag=10:1) was carried out so that it might become the thickness of 0.6 micrometers, on this cathode, the vacuum evaporation of Ag was carried out by the thickness of 0.5 micrometers, and the organic EL element was formed. The light transmittance (solid line) of an anode plate and the emission spectrum (one-point dashed line) of an organic EL element are shown in drawing 11.

[0042] The organic EL element was formed like the example 3 of comparison except carrying out the vacuum evaporation of the silver by the thickness of 8nm on example 7ITO, carrying out the spatter of the ITO by the thickness of 0.1 micrometers further on it, carrying out patterning like drawing 1 , and considering as an anode plate. The surface electrical resistance of this anode plate was 0.10ohm/\*\*. The light transmittance (solid line) of an anode plate and the acquired emission spectrum (one-point dashed line) of an organic EL element are shown in drawing 12.

[0043] The organic EL element was formed like the example 3 of comparison except the vacuum evaporation of the silver being carried out by the thickness of 4nm on example 8ITO, carrying out the spatter of the ITO by the thickness of 0.1 micrometers, carrying out the vacuum evaporation of the silver by the thickness of 4nm, carrying out the spatter of the ITO by the thickness of 0.1 micrometers further, carrying out patterning like drawing 1 , and considering as an anode plate. The surface electrical resistance of this anode plate was 0.13ohm/\*\*. The light transmittance (solid line) of an anode plate and the acquired emission spectrum (one-point dashed line) of an organic EL element are shown in drawing 13.

[0044] The organic EL element was formed like the example 3 of comparison except the vacuum evaporation of the platinum being carried out by the thickness of 4nm on example 9ITO, carrying out the spatter of the ITO by the thickness of 0.1 micrometers, carrying out the vacuum evaporation of the silver by the thickness of 4nm, carrying out the spatter of the ITO by the thickness of 0.1 micrometers further, carrying out patterning like drawing 1 , and considering as an anode plate. The surface electrical resistance of this anode plate was 0.15ohm/\*\*. The light transmittance (solid line) of an anode plate and the acquired emission spectrum (one-point dashed line) of an organic EL element are shown in drawing 14.

[0045] The result which searched for the power efficiency of the organic EL element formed in the example 3 of comparison and the examples 7-9 as mentioned above is combined with the surface electrical resistance of an anode plate, and is shown in Table 2. In addition, the voltage impression time of one pulse is expressed for 10ms, 100 microseconds, 1 microsecond, and 10ns among Table 2.

[0046]

table 2 [ ] surface electrical resistance Power efficiency (lm/W)

(omega/\*\*) 10ms 100 microseconds 1microsecond 10ns The example 3 of comparison 20.0 1.32 1.11 0.90 0.73 Example 7 0.10 1.44 1.25 1.14 1.04 Example 8 0.13 1.52 1.36 1.24 1.11 Example 9 0.15 1.55 1.38 1.26 1.14

[0047] Table 2 shows that the organic EL element of examples 7-9 shows high power efficiency as compared with the organic EL element of the example 3 of comparison. This can be said for examples 7-9 to be the effects acquired since it was not necessary to raise a light transmittance over a full wave length region. Moreover, it turns out that the effect is remarkable especially under the conditions that voltage impression time is short.

[0048]

[Effect of the Invention] As explained in full detail above, the organic EL element of this invention has the electrode of the low light-transmission nature of surface electrical resistance, and shows high power efficiency.

**\* NOTICES \***

Japan Patent Office is not responsible for any damages caused by the use of this translation.

1.This document has been translated by computer. So the translation may not reflect the original precisely.

2.\*\*\*\* shows the word which can not be translated.

3.In the drawings, any words are not translated.

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**DESCRIPTION OF DRAWINGS**

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**[Brief Description of the Drawings]**

**[Drawing 1]** It is the schematic diagram showing the example of a pattern of an anode plate of the organic EL element of this invention.

**[Drawing 2]** It is the schematic diagram showing the example of a pattern of the anode plate and cathode of the organic EL element of this invention.

**[Drawing 3]** It is the graph which shows the emission spectrum (one-point dashed line) of the organic EL element of the example 1 of comparison, and the light transmittance (solid line) of an anode plate.

**[Drawing 4]** It is the graph which shows the emission spectrum (one-point dashed line) of the organic EL element of the example 2 of comparison, and the light transmittance (solid line) of an anode plate.

**[Drawing 5]** It is the graph which shows the emission spectrum (one-point dashed line) of the organic EL element of an example 1, and the light transmittance (solid line) of an anode plate.

**[Drawing 6]** It is the graph which shows the emission spectrum (one-point dashed line) of the organic EL element of an example 2, and the light transmittance (solid line) of an anode plate.

**[Drawing 7]** It is the graph which shows the emission spectrum (one-point dashed line) of the organic EL element of an example 3, and the light transmittance (solid line) of an anode plate.

**[Drawing 8]** It is the graph which shows the emission spectrum (one-point dashed line) of the organic EL element of an example 4, and the light transmittance (solid line) of an anode plate.

**[Drawing 9]** It is the graph which shows the emission spectrum (one-point dashed line) of the organic EL element of an example 5, and the light transmittance (solid line) of an anode plate.

**[Drawing 10]** It is the graph which shows the emission spectrum (one-point dashed line) of the organic EL element of an example 6, and the light transmittance (solid line) of an anode plate.

**[Drawing 11]** It is the graph which shows the emission spectrum (one-point dashed line) of the organic EL element of the example 3 of comparison, and the light transmittance (solid line) of an anode plate.

**[Drawing 12]** It is the graph which shows the emission spectrum (one-point dashed line) of the organic EL element of an example 7, and the light transmittance (solid line) of an anode plate.

**[Drawing 13]** It is the graph which shows the emission spectrum (one-point dashed line) of the organic EL element of an example 8, and the light transmittance (solid line) of an anode plate.

**[Drawing 14]** It is the graph which shows the emission spectrum (one-point dashed line) of the organic EL element of an example 9, and the light transmittance (solid line) of an anode plate.

**[Description of Notations]**

1 ... Substrate

2 ... Anode plate

3 ... Cathode

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[Translation done.]